NASA

THE BEST-READ VOLCANO

Skill and luck combined recently to paint one of the most detailed portraits yet of an erupting volcano

BY SUSAN WEST

In the fields of observation, chance favors only the mind that is prepared.

— Louis Pasteur

Pasteur's ghost must be smiling. Because of a combination of prepared minds and a lot of chance, the recent eruption of La Soufrière on St. Vincent Island in the Caribbean may be the most documented volcanic event ever.

It's an impressive story of scientific coordination. When the 4,048-foot volcano 450 miles southeast of Puerto Rico began erupting April 13, local officials had known of the impending disaster for at least five hours. By April 14, a team of local and U.S. scientists had constant touch on the volcano's pulse, and on April 17, when the most vigorous explosion occurred, it was photographed, recorded and analyzed from satellite, airplane, ship and ground.

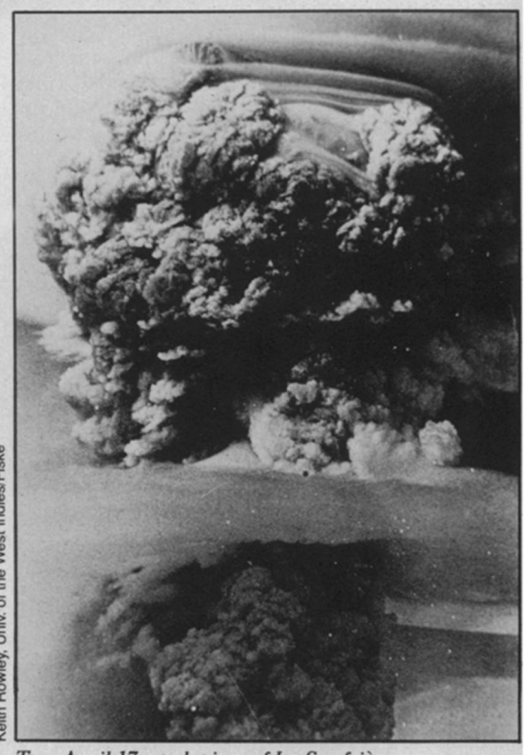
"It was fabulous. I mean, really. An extraordinary situation," says ground team member Richard Fiske of the Smithsonian Institution. "It's very unusual that the seismic data are there and the visual observations and then the aerial observations — that's the really exciting aspect of this particular eruption. Very few, if any... I would say no eruption will be as well documented in that regard."

The stage was set in 1971. In November of that year, a 300-foot-diameter lava island appeared in the middle of La Soufrière's mile-wide crater lake. Though the island was formed by the eruption of magma from the crater floor, there was no explosion and only very low seismic activity was recorded. Following that event, a team from the Seismic Research Unit of the University of the West Indies in Trinidad set up two seismographs 3 kilometers and 9 km from the crater and began systematic measurements of the crater lake temperature. The seismic network was later extended from Trinidad to the island of Dominique, just south of Guadeloupe, and linked by telemetry to the observatory in Trinidad. "We knew something was cooking since 1971," says Haraldur Sigurdsson of the University of Rhode Island, a former member of the Seismic Research Unit.

In mid-1978, the Trinidad researchers noticed an increase in seismic activity and a rise in the lake temperature. Due to this advance notice, they weren't caught off guard when seismic activity began to increase April 12. According to their report, the first "abnormal event" was a strong quake at 11:16 a.m. (local time). By 7:00 p.m., there were about 15 identifiable quakes per hour. By 8:00 p.m., the activity had built to a continuous tremor and by 10 p.m., it was "saturating" both instruments. That evening, during a party that was going on in the research unit, someone observed the records and at midnight the seismologists called St. Vincent Premier Milton Cato. The first explosion occurred at 5:00 a.m. April 13.

"In effect," says Sigurdsson, "they had a definite indication of the oncoming eruption at 8:00 p.m. It was a very rare case where [a warning] was actually seen and acted on."

By now, the wheels were rolling. Cato ordered an evacuation of the area; about 20,000 of the island's nearly 110,000 people were moved from the northern end of St. Vincent. Notified of the explosion, Paul Krumpe, the science liaison in the Office of U.S. Foreign Disaster Assistance of the Agency for International Development, called Sigurdsson and Fiske and arranged for them to join the University of the West



Keith Rowley, Univ. of the West Indies/Fiske

Top: April 17 explosion of La Soufrière as it breaks through the cirrus layer photographed from NASA research plane at 10,500 feet. Above: Closer view of same explosion from a private plane. Cloud layering possibly due to shock waves.

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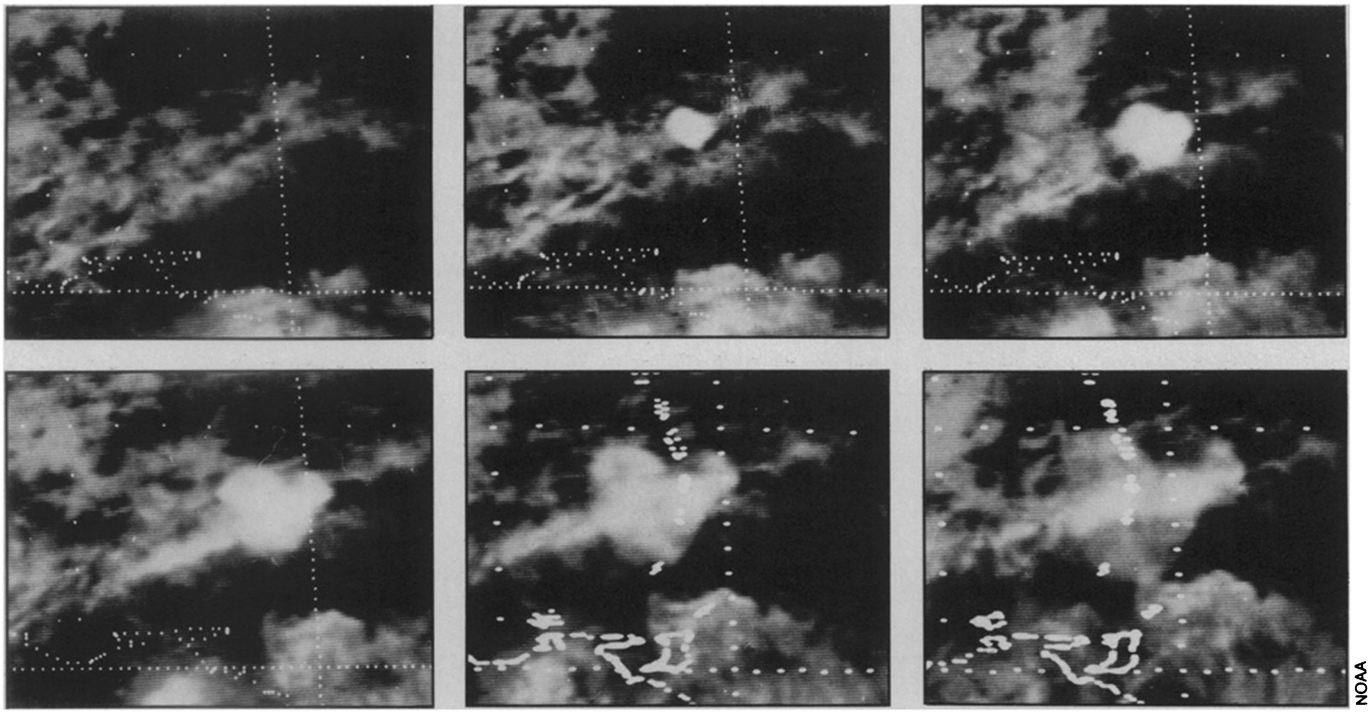


NOAA

Infrared weather satellite photos of April 17 explosion taken every hour from 4:30 p.m. to 9:30 p.m. local time. Rising and enlarging cloud, estimated to be about 150 nautical miles wide, drifts with the winds northeastward to North Africa. White dotted lines mark latitude, longitude, coast of South America, position of the islands.

Indies team. The Coast Guard was requested to have ships at sea collect ash fall on pieces of paper and mail them to the Seismic Research Unit.

The two U.S. scientists and the five-membered Trinidad team led by J. F. Tomblin took rock and ash samples, set up more seismic stations and checked one of two tilt stations that had been in place since March 1977. The tilt stations (one was too close to the summit for comfort) were set up to measure "inflation." According to other studies, as magma builds in the volcano, the volcano swells, causing measurable changes in elevation. In this case, according to Fiske, no inflation was detected.

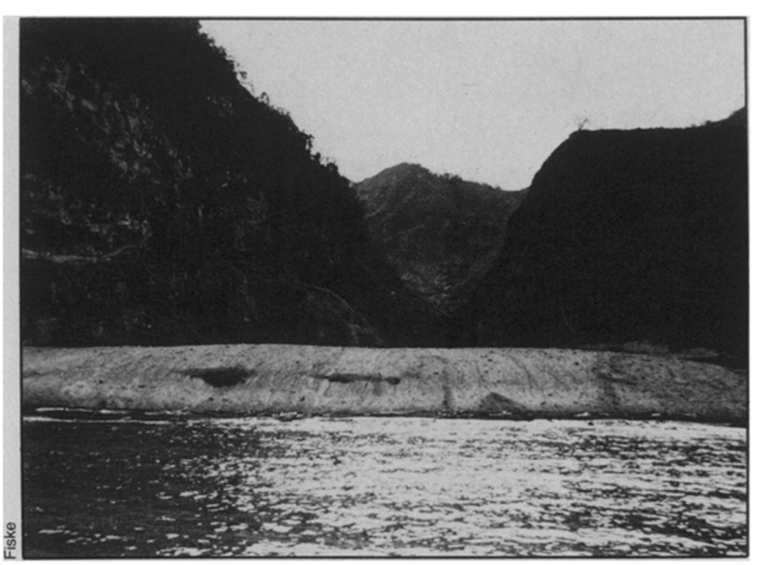
Three more explosions on April 13 dropped about 4 centimeters of ash at the foot of the volcano and showered ash on Barbados, 600 miles to the east. Two strong explosions occurred April 14. One produced a glowing avalanche of ash and gas that rolled down a river valley and continued 6 km to 8 km out to sea.

High in the sky amid all this commotion, the National Oceanic and Atmospheric Administration's geostationary weather satellite SMS 1 had been recording all with its omniscient infrared eye. At Krumpe's request, NOAA made film loops of the satellite pictures of the explosions that showed the way the clouds spread through the atmosphere. According to NOAA's Art Kruger, most of the eruptions broke through the cirrus layer and seem to have sent debris to at least 17 km.

In the meantime, a NASA research plane had been on a "ground truth" mission in Brazil for the stratospheric-examining satellite SAGE (SN: 2/24/79, p. 117). When SAGE coordinator Pat McCormick was alerted, he had the plane delayed in its stopover in Barbados. About 5 p.m. on April 17, when the lidar-equipped craft (lidar measure stratospheric dust) was 50 miles from St. Vincent, La Soufrière put on its most spectacular show. The explosion, which researchers believe was the most violent of the series, "looked like a nuclear explosion" McCormick says. It rose to 18.7 km and penetrated the stratosphere. While the ground team recorded the explosion and collected falling debris, the plane sampled the plume and followed it in the troposphere as it traveled east, northeast toward North Africa. On April 18, the plane detected a "nice, strong stratospheric layer" 0.5 km to 3 km thick moving west, southwest. McCormick said that scattering ratios, a measure of particle distribution, were as high as 50. (For clear air the ratio is 1.)

Based on the samples collected on the periphery of the cloud and in the downwind plume, McCormick says the April 17 cloud was "dry"—containing little sulfuric acid—and was composed of two sizes of particles. The larger particles, 0.8 micrometer in diameter, contained heavy metals such as iron, McCormick said, and the smaller particles, about 0.1 μm, contained aluminum and silica. The larger particles will drop out of the atmosphere, but the smaller ones may remain in the stratosphere for months or years and will

Continued on page 318



Fiske

Smooth black ledge of rock in center marks the seaward edge of deposit from now-cooled April 14 glowing avalanche.

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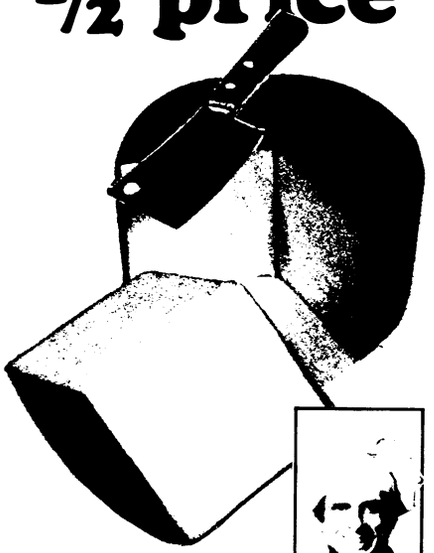

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. . . Chinese chemists

rochemical reactions and have done important basic research on catalysis, surface properties and molecular dynamics. Recently, he says, they developed a high-pressure liquid chromatography column of especially high efficiency.

More than 27,000 Chinese work in chemical research and engineering, excluding the universities, Li estimated after consultation with the others in rapid Chinese. Li is deputy secretary-general of the Chinese Academy of Sciences and vice-chairman of two chemistry organizations — the Chinese Chemical Society and the Chinese Chemical, Industrial and Engineering Society. He explained that there are 20 institutes of chemistry in the Chinese Academy of Sciences and more than 180 in the governmental ministries of industry, agriculture and medicine. In addition, many universities have chemistry or chemical engineering departments.

Whatever the location of the laboratory, the Chinese government foots the research bill. "As long as the research program is recognized as important, you can have money," Gu said. "You don't have to worry." He explained that a national planning committee delegates money to the academy and ministries, who then divide it among the institutes. "You don't have to ask for money all the time," Gu said. "It comes right away."

When asked about women in Chinese science, Li said, "There are a lot of women scientists, especially in chemistry and biology and at the universities." Although only one woman was included in the delegation attending the Honolulu meeting, both Li and Gao estimated that, in all, about half the chemists are female. Gao said that currently there are fewer women than men at the top. "They have the same opportunity, but due to tradition only a few women [formerly] were well educated. So not very many are [now] in the highest rank," Gu explained. "But we will have many, I am sure."

The chemists went on to explain that daycare for a child is inexpensive — about $2.50 per month. That amount is less than 3 percent of the average graduate scientist's salary, and in most families both parents work. Any thought of salaries, the chemists cheerfully pointed out, must include the fact that there is no income tax.

The scientists are looking forward to more information exchange. Plans are underway to send scientists to visit U.S. laboratories, to invite U.S. scientists to lecture in China and to continue exchanging technical journals. In an exchange program next year, more than 500 Chinese students plan to attend U.S. universities.

"We have a bright future, but we have a lot of work. It will take competence to carry out the task and help from American friends," Li says. "This meeting is a good way of beginning. We believe the future will increase contacts among scientists of all countries." ☐

. . . La Soufrière

be carried around the world.

Since two smaller explosions on April 22 and 25, La Soufrière has been quieting. But for the scientists activity is just beginning. Using samples of rock and ash gathered after each explosion, researchers will determine the amount and type of material spewed from the volcano. By combining satellite data and aircraft data, the particle and gas composition, the distribution, and the weather effects of the volcanic plumes will be mapped. Together with the continuous seismic record, the pieces will be fit into a giant puzzle that may help explain volcanoes such as La Soufrière.

A major question is the cause of the eruption. La Soufrière and its companions on Guadeloupe and Martinique sit on a subduction zone where the Americas plate crunches beneath the Caribbean plate. The material released in these volcanoes is believed to be rock that has melted under pressure and depth rather than the fundamental magma like that which oozes from Hawaiian "hot spot" volcanoes. The question about this eruption, say Fiske and Sigurdsson, is whether it is fed by the rise of new magma from depth or by material already in the volcanic conduit system. In the latter case, Sigurdsson explained, the eruption might be a phreato magmatic explosion — the result of water from the crater lake seeping into the magma source and expanding explosively into steam.

The answer may be as important for human safety as it is for science. If the eruption is the product of new magma — which may indicate activity along the subduction zone — then it may herald a longer period of eruption as well as similar events in the other volcanoes of the island arc. If it is due to the interaction of the lakewater and magma, then it will probably end when the 20-million-cubic-meter lake is used up, says Sigurdsson.

The composition of the rocks and of any liquid inclusions in the magma may provide the answer. For instance, if the silica content of the rocks varies significantly from that of earlier eruptions, it may indicate that new magma was present, says Fiske. By electron microprobe and mass spectroscopy, Sigurdsson will look for the presence, amount and type of liquid, the level of pressure needed to introduce it and the mineral composition of the rock. The early data, he says, favor phreato magmatic activity, but definite answers won't come for at least six months. If the eruption is found to be caused by the lake, says Sigurdsson, one solution might be to drain it. The lake of a volcano in Indonesia was drained, he says, and activity continued quietly and without loss of life.

A scientific basis for such a decision will not be soon coming, however. For now, scientific triumph notwithstanding, for the 20,000 evacuees, La Soufrière means months of displacement, ash-covered crops and the destruction of livestock. ☐